Evaluation of Waste Transfer Operation at TPS Patrakomala Bandung City

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Abstract. For years Bandung City has problems in its municipal waste management, due to a limitation of service coverage and transfer station (TPS) facilities and its management. One of the government's efforts to solve the problems was by implementing a waste-free area program, known as Kawasan Bebas Sampah (KBS). One way to support the KBS program is by having a waste transfer station with reduce-reuse-recycle treatment facilities (TPS 3R). The purpose of this study was to identify the potential TPS to be functioned as TPS 3R and evaluate its transfer operation system. This study was conducted by selecting potential TPS, collecting its infrastructure data, supporting equipment, and waste vehicles by observation, interview, and physical measurements (for 8 days) to identificating its existing operational and evaluating its collection-transfer operation system according to Regulation of The Minister of Public Works No 03, 2013. The criteria selection was developed based on government regulations, stakeholder interview, and related policies. It was identified that TPS Patrakomala was the most potential TPS to be functioned as TPS 3R, but still operates without scheduled operation system. In TPS Patrakomala, the waste vehicles consisted of four conventional handcarts, eight motor bikes, and two pick-up cars per day, collecting waste respectively 1,4; 2,6; 3,6 m^3/trip, which were done 2 trips/day. At the end, a city dump truck will pick up the waste from TPS Patrakomala once or twice a day, with a capacity of either 10, 13 or 14 m^3. Even with the average waste transported were above the truck capacity (respectively 20; 22; 26 m^3/truck/trip) there were still some waste unstransported from TPS. In the near future, the result of this study will be used to design a TPS 3R which is expectedly contribute to the improvement of wast managementin Bandung City.

Keywords: *transfer station, TPS 3R, Kawasan Bebas Sampah, Bandung City, municipal waste, waste vehicles, waste collection, waste transfer*.

1 Introduction

Bandung City has problems in its municipal waste management, due to limitation of service coverage and transfer station (TPS) [4]. It is also spoken by the CEO of PD Kebersihan Kota Bandung, Dedi Nurdiana, acknowledged TPS in Bandung is minimal. This resulted waste piled up in some place. Ideally in every sub

district at least have three TPS, while now still two. However, he said that parties difficult to build new TPS because of the constrained availability of land [11]. In addressing the issue of waste problems Bandung's Government has 3R (reduce, reuse, recycling) activities [10]. One of the most common indicator in evaluating the performance of 3R activities is the level of cleanliness which can be seen visually, although waste management syste effectiveness should be measured from operational handling and waste reduction. There are various ways in waste management with 3R activites, even this activities involves elements of society [10]. The clean environment is essentialy the goal of every urban waste management [1].

The current program that involved 3R activities and society is a Waste-Free Area known as Kawasan Bebas Sampah (KBS). Kawasan Bebas Sampah (KBS) is one of the many components of the medium-term development program (RPJMD) Bandung City. Kawasan Bebas Sampah is a collaboration program between Bandung's Government and Badan Pengelola Lingkungan Hidup (BPLH) Bandung, aiming at making 6 waste-free areas per year since 2013. The existence of waste-free area with well waste management actually has become the target of Bandung's Government [1]. The target in 5-year period of the reign of Mayor Ridwan Kamil, there should be developed 30 waste-free area throughout Bandung City at 2018 [1]. Within the last two years there are already 12 waste-free models, which are located scattered within 12 districts, namely Sukasari, Bojong Kaler, Rancasari, Lengkong, Bandung, Batununggal Kidul, Mandalajati, Sumur Bandung, Cibeunying Kaler, Regol and Sukajadi [9].

In order to support the running of KBS program, required the presence of waste reducing, reusing and recycling activities at the sources (community) and/or having a waste transfer station with reduce-reuse-recycle facilities (TPS 3R) to support the community [1]. As described above there are a few things which become the background the needed of TPS 3R, first the problem of waste that piled up due the limitiation of TPS, secondly it is difficult to make a new TPS due availability of the land, and third there is a program that running 3R activities in community and required a facilities to support them which is TPS 3R. Based on interviewed with KBS parties, the community become more motivated to do 3R if supported with well-condition of TPS. For example the community already sorting the waste at home, but when taken by waste collector is mixed up in the waste vehicles, so the waste is also mixed up in TPS.

Further, the presence of TPS 3R will facilitied the need of community, so that waste will be processed and reduced. This will work if it is supported by the existence of operational mangement system in TPS 3R. There are two main focuses in waste management in TPS 3R which are waste reduction (waste

minimization) and waste handling.Waste minimization consist of the waste reuse, reduce, and recycle, so only residue that will transported to landfill. Waste handling consist of sorting, collecting, hauling and waste processing [6]. The result of this study will be used to design TPS 3R, covering both waste reduction and waste handling.

2 Methods

This study was conducted as described in Figure 1.

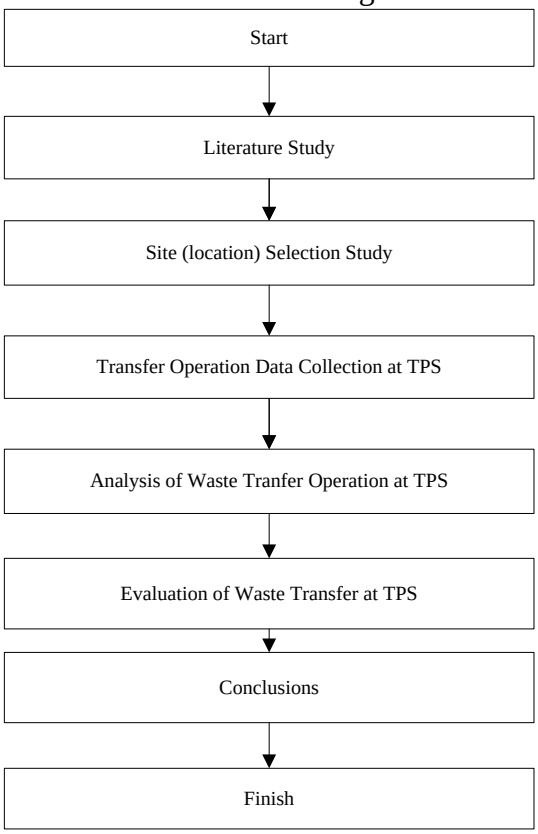

Figure 1 Method Flow Charts.

2.1 Site (location) Selection Study

Site selection study is important since the TPS 3R must meet the thecnical aspects of regulations and to ease the operational TPS 3R should be in KBS area [7]. To compile those requirement the selection was conducted using five criteria. The first and second criteria resulted from interviews and study on KBS program. The first criterion is to select TPS which are not a TPS 3R, TPS market, hospital,

factory, commercial and/or institution. The second criterion, selects the location of TPS within KBS. The third criterion is to select land area > 200 m^2 as refered in the government regulation which is Regulation of The Minister of Public Works No 03, 2013 [5]. The forth criterion selects a TPS located in a land owned by Government of Bandung for the ease of operation. The fifth criterion selects a TPS that was priorites to be repaired but was still has to be done.

2.2 Transfer Operation Data Retrieval at TPS

At this stage the operational data collection aims to find out existing condition, waste collection and transport operation at TPS. Exsisting conditios are infrastructure, facilities and authority. Waste collection and transport are type, capacity, waste volume, time of the operation, activities of waste collection, and transport at selected TPS. Data-related to operation of waste collection are waste vehicle types, obtained through observation, measurement of waste vehicle capacity, and waste volume collected, operational time counting, and interview related activity of waste collection. Data-related operations of the waste transport are truck types obtained through observation, measurement of truck capacity, waste volume transported, operational time counting, and interview related activity of truck in TPS. Data collection was done for eight days.

2.3 Analysis & Evaluation of Waste Transfer Operation at TPS

In attempt to improved the TPS to TPS 3R became necessary to analysis and evaluate its existing conditions (infrastructure, facilities and authority) and operation system at TPS reffering to The Minister of Public Works No 03, 2013. There are several parameters that need to be evaluated such as land area and its capacity, availability of sorting and separate waste facilities, container, its operation should not interfere traffic and esthetic, do not pollute the environment and scheduled operation system.

According to Thecnical Guidance for the Realization of KBS Program [1] and Regulation of The Minister of Public Works No 03, 2013 [5] the data types, number, capacity, volume of waste collected, was used to find out suitability of collection operational in TPS and its analysis to sinchronized the transport operation which are type, number, capacity, volume of waste transported from TPS. The result of evaluation will be used to support operational of TPS 3R and other related data will be used to design or improve TPS 3R.

3 Analysis dan Evaluation

3.1 Site Selection

In the site (location) selection study, there were some result by using five criteria, described as follows:

1. Based on PD Kebersihan's data, in 2015 there are 159 TPS, comprise of 10 TPS 3R, 62 TPS markets, hospitals, factories, commercials and or institutions. Thus, from this first criterion. There are 87 TPS are eligible for this study.
2. Then with the second criterion, out of 87 eligble TPS, 45 of them are located in Kawasan Bebas Sampah (KBS) area.
3. Then, of the 43 TPS, 16 TPS meets the third criterion (land is owned by Bandung City Government) and 7 of them are the priorites to be repared namely TPS Komplek Sadang Serang, TPS Pasteur, TPS Kebun Binatang, TPS Patrakomala, TPS Ambon, TPS Gumuruh, and TPS Pagarsih.
4. The fourth criterion is the land must be greater than 200 m^2. There are 4 TPS which meets this criterion, namely TPS Komplek Sadang Serang, TPS Kebun Binatang, TPS Patrakomala, and TPS Pagarsih.
5. The fifth selects a TPS that was priorites to be repaired but was still has to be done, then produced TPS Patrakomala as the most potential location for this study.

Table 1 Potential TPS

No	Name	Location	Land Ownership (Pemkot)	Land Area > 200 m^2	Non Technical Aspect
1	TPS Komp. Sadang Serang	Jl Sadang Serang	√	√	
2	TPS Pasteur	Jl Dr Djunjunan	√		
3	TPS Kebun Binatang	Jl Tamansari	√	√	
4	TPS Patrakomala	Jl Patrakomala	√	√	√
5	TPS Ambon	Jl Ambon	√		
6	TPS Gumuruh	Jl Gumuruh	√		
7	TPS Pagarsih	Jl Pagarsih	√	√	

Based on the table above it can be concluded that TPS that meet the criteria to function to TPS 3R is TPS Patrakomala.

During the process of third stages site selection study, it was found that several TPS were already relocated or their functions have changed. It also can be analyzed that according to the Research and Development Division of PD Kebersihan, currently there is no formal authority responsible for updating data related to TPS. Consequently, in some cases written data owned by PD Kebersihan are not the same with the existing conditions.

3.2 Existing Conditions of TPS Patrakomala

TPS Patrakomala is located in Merdeka Sub-district, Sumur Bandung District. To the West it is bordered by the Merdeka District Office, to the North there is the Tongkeng Park, to the East is Jl. Tongkeng, and to the South is Jl. Patrakomala. Location of TPS Patrakomala can be seen in Figure 2 (in the picture TPS Patrakomala, also known as TPS Tongkeng).

Figure 2 Location of TPS Patrakomala

Land area available for TPS Patrakomala is 480 m^2. According to Regulation of The Minister of Public Works No 03, 2013 [5], the area for TPS 3R should be more than 200 m^2. Therefore TPS Patrakomala has meet the requirement. Currently the used area is 110 m^2 with a length of 11 m, width of 10 m, and a height of wall 2 m. The width of access road (Jl. Patrakomala) is 6 m. See Figure 3.

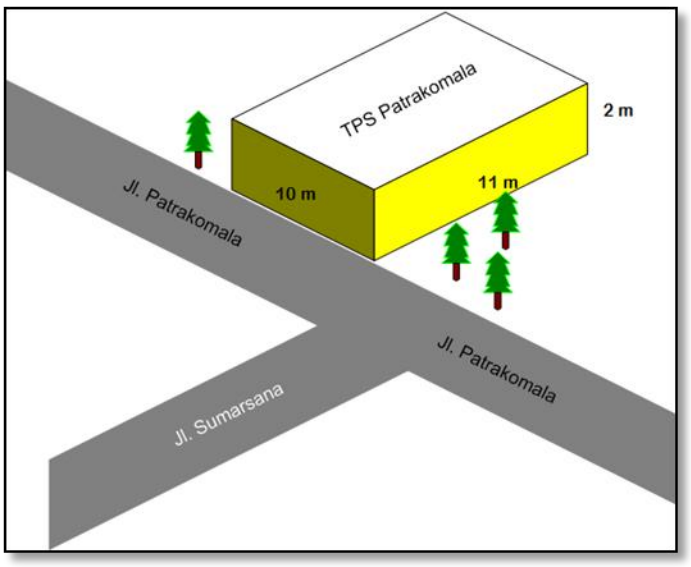

Figure 3 Currently Used Area 3D TPS Patrakomala

There was no waste container in TPS Patrakomala. According to statement of CEO PD Kebersihan, Dedi Nurdiana, he recommend that TPS should be equipped with a container, not only the walls [11]. It become a consideration in designing TPS 3R since it also require the needed of area or container for residue. Then in TPS Patrakomala there was no gate for waste vehicles and waste transport, so that vehicles can directly access TPS, as long as there is no other vehicles at the same time. If workers are doing the unloading; when the TPS is full, other vehicles had to wait in line. It can be analyzed if it too many vehicles are lining up, it will distrupt/interfere the traffic, this is contrary to the regulation, refered to Regulation of The Minister of Public Works No 03, 2013 [5] the activites of TPS should not interfere the traffic. The limitation in some facilities will need an improvement to run as TPS 3R.

3.3 Waste Tranfer Operational System

3.3.1 Waste Collection

During the 8 days of observations there were 32 waste vehicles. For the ease of observation vehicles are being labelled, and it was found to be 11 conventional handcarts, 16 motor bikes, and 5 pick-up cars. Refered to Regulation of The Minister of Public Works No 03, 2013 [5] for area with relatively flat topography (slope < 5%) were able to use non-collecting machine such as traditional handcarts, whereas for the topography with the slope > 5% can use motorbikes. So for this area with relative flat topography was able to traditional handcarts.

Figure 4 Types of Waste Vehicles

The entire waste vehicles did not operate everyday, therefore data of the average number of waste vehicles per day need to be counted. The average number of waste vehicles per day can be seen in Table 2.

Table 2 Number of Waste Vehicles

Types	Day								Average number per day
	1	2	3	4	5	6	7	8	
Traditional handcarts	3	7	8	3	3	3	2	2	4
Motor bikes	5	11	7	8	9	8	7	6	8
Pick-up cars	0	4	2	2	1	3	0	0	2
Average									14

From the table above the average number of waste vehicles were found to be 4 conventional handcarts, 8 motor bikes, and 2 pick-up cars per day. It also can be seen compare to total number of each waste vehicles, motorbikes is the most operated everyday. Refered to Regulation of The Minister of Public Works No 03, 2013 [5] waste collection need to be done by 1-4 trip/day. Based on observation the average of waste collection were 2 trip/day.

The dimensions and capacity measured can be seen in Table 3.

Table 3 Dimensions and Capacity of Waste Vehicles

Types	Dimensions P (m) x L (m) x T (m)		Capacity(m^3)	
	Minimum	Maximum	Minimum	Maximum
Traditional handcarts	1,50 x 0,75 x 0,90	1,55 x 1,25 x 1,20	1,01	2,33
Motor bikes	1,50 x 0,75 x 1,00	1,60 x 1,10 x 1,42	1,13	2,5
Pick-up cars	2,00 x 0,75 x 1,00	4,30 x 1,90 x 0,60	1,5	4,9

Based on the table above it can be concluded that pick-up car can carry or collect more waste as compared to other waste vehicles. The waste volumes carried or collected can then be calculated based on the dimension of the vehicles as follows:

$$\frac{(length\,cm\,x\,width\,cm\,x\,average\,waste\,height\,cm)}{10^6} \quad (1)$$

Then the waste volume from each waste vehicles can be seen on the Table 4.

Table 4 Waste Volumes Collected

Types	**Waste Volumes (m^3/trip)**
Traditional handcarts	1,4
Motor bikes	2,6
Pick-up cars	3,6

Based on the table above it can be concluded that the waste volume carried or collected by a pick-up is higher as compared to other waste vehicles. Further, its will become a consideration in operational of TPS 3R since motorbikes found to be the most operated also can carry more waste.

From the Table 2 and 4, the average that collected to TPS Patrakomala from 4 handcarts with average vaste volume collected 1,4 m^3/trip, from 8 motorbikes with average vaste volume collected 2,6 m^3/trip and from 2 pick-up cars with average vaste volume collected 1,4 m^3/trip, and the average of either waste collection were 2 trip/day it calculated that the average waste collected is 67,2 m^3/day.

3.3.2 Activities & Operational Time of Waste Collection at TPS

Based on the interview with waste collectors at the TPS, activities of waste collection start from 6 AM until 5 PM. Because TPS operated with unscheduled operation system, then the waste collector adjusted their collection time by itself. The TPS has no gate and also an authority might caused the existence of waste collector that enter to TPS after 5 PM. Therefore there will be waste staying overnight in TPS Patrakomala. Operational schedule and officer is required to adjust activities of waste collector and trucks that will pick up waste. The objective is to prefent waste for staying overnight in TPS. The average time to collect the waste for each waste vehicle in their service can be seen in Table 5.

Table 5 Waste Collection Times per

Day	Handcarts (hour:minute)	Motorbikes (hour:minute)	Pick-Up Car (hour:minute)
1	1:06	1:24	-
2	2:08	1:55	1:40
3	1:04	1:28	1:37
4	1:10	2:05	6:20
5	2:09	1:25	2:15
6	2:46	1:29	4:04
7	0:59	1:41	-
8	1:05	1:34	-
Average	1:33	1:37	3:11
Maximum	2:46	2:05	6:20
Minimum	0:59	1:24	1:37

From the table above it can be seen that the average time for handcarts and motorbikes to collect waste was faster than pick-up cars. It was due to the volume of waste collected and the ability of the waste collector itself. Since motorbikes operated faster, even from Table 4 the waste that collected using motorbikes almost twice as waste collected from using handcarts, the average collection time relatively same. Therefore the waste volume collected using handcarts is not as much as collected by motorbikes and pick-up cars, it also stated in the Table 4. Those were the reason why waste collector who use handcarts can have faster time in waste collection than pick-up cars.

Unloading and loading activities counted at TPS Patrakomala can be seen in Figure 6.

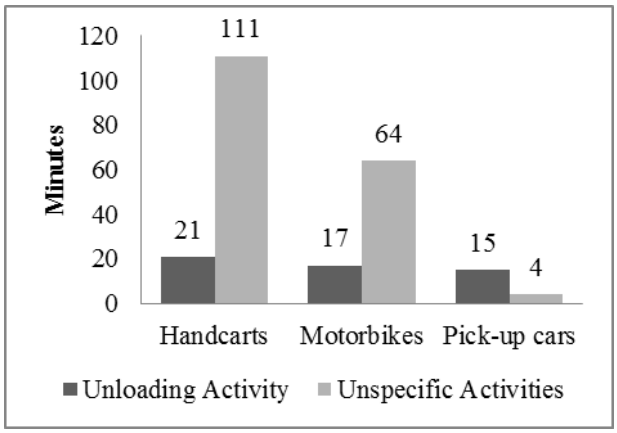

Figure 5 Average Time of Waste Collector-Waste Vehicles Activities at TPS

The average time needed to unloaded for waste collector who used handcarts, motorbikes and pick-up cars were respectively 21, 17, and 15 minutes. There are other unspecific activitessuch as queuing time for unloading, cleaning the certain vehicles, and resting. Queuing time occurs when TPS was full of waste so other waste collectors have to wait until the waste in TPS picked up by trucks. The average time for irrelevant (unspecific) activities of a waste collector who used handcarts, motorbikes and pick-up cars are respectively 111, 64, and 4 minutes. The waste collector using handcarts need a longer time to rest than the others, because they have to walk from sources to TPS. Data on time needed by waste collectors will be adjusted for recommendation of operational activity scheduling of waste collector, so there are no queues that could interfere the access of dump truck to enter the TPS, so the waste that already collected in TPS can be immediately picked up by dump truck.

3.3.3 Waste Transportation

Waste transported done by dump trucks, to transport waste from TPS Patrakomala to Sarimukti Landfill was conducted 1-2 trips/day. The capacity of a dump truck and the waste volume transported to the landfill can be seen in Table 6.

Table 6 Truck Capacity and Waste Volume Transported

No	Date	Types	Truck Capacity (m^3)	License	Waste Volume Transported (m^3)
1	17-Apr-16	*Dump truck*	14	R 1780 AB	26
2	18-Apr-16	*Dump truck*	14	R 1780 AB	27

No	Date	Types	Truck Capacity (m^3)	License	Waste Volume Transported (m^3)
	18-Apr-16	*Dump truck*	14	R 1780 AB	26
3	19-Apr-16	*Dump truck*	14	R 1780 AB	26
	19-Apr-16	*Dump truck*	14	R 1780 AB	26
4	20-Apr-16	*Dump truck*	10	D 8253 C	20
5	21-Apr-16	*Dump truck*	14	R 1780 AB	26
6	22-Apr-16	*Dump truck*	13	F 9179 AA	22
7	23-Apr-16	*Dump truck*	14	R 1780 AB	26
	23-Apr-16	*Dump truck*	14	R 1780 AB	26
8	24-Apr-16	*Dump truck*	14	R 1780 AB	26

From the table above we can analyzed that to maximize the amount of waste transported to the landfill, the truck driver fills the container twice as its normal capacity. The truck capacity is either 10, 13 or 14 m^3, whilst the average of waste transported to landfill were respectively 20, 22 and 26 m^3/truck/trip. Refered to the average waste collected was 67,2 m^3/day, it can be analyzed even the average of waste trandported to landfill as mentioned above, there were still some waste unstransported from TPS.

The waste in truck container was fully compacted its also raises problem such as dripping of leachate from the sides of truck and odor pollution, since the waste are mostly garbage [3].

The dimensions of truck measured can be seen in Table 7.

Table 7 Dump Truck Dimension

Longest				Shortest			
Dump truck	**L**	**W**	**H**	***Dump truck***	**L**	**W**	**H**
	4 m	2,2 m	3,05 m		3,5 m	2 m	2,7 cm

Based on observation and refered to Table 3 and 7, with the existing length of TPS metre, ideally only 2 waste vehicles that can unload the waste at the same time as the truck which arrived to fill the container. Further, data from Table 3 and 7 will be used and adjusted to design a loading and unloading space at TPS 3R.

3.3.4 Activities & Operational Time of Truck at TPS

Currently, in TPS Patrakomala waste is transported to landfill once or twice per day. Truck arrival time and activities of waste filling can be seen in Table 8.

Table 8 Activities & Operational of Truck at TPS

No	Date	Type	License	Arrival Time	Departure Time from TPS	Filling Process (hours)
1	17-Apr-16	*Dump truck*	R 1780 AB	6:30	8:40	2:10
2	18-Apr-16	*Dump truck*	R 1780 AB	5:00	7:47	2:47
	18-Apr-16	*Dump truck*	R 1780 AB	12:05	14:23	2:18
3	19-Apr-16	*Dump truck*	R 1780 AB	5:00	7:45	2:45
	19-Apr-16	*Dump truck*	R 1780 AB	12:32	14:41	2:09
4	20-Apr-16	*Dump truck*	D 8253 C	11:08	13:57	2:49
5	21-Apr-16	*Dump truck*	R 1780 AB	11:50	14:10	2:20
6	22-Apr-16	*Dump truck*	F 9179 AA	8:01	9:30	1:29
7	23-Apr-16	*Dump truck*	R 1780 AB	5:00	7:30	2:30
	23-Apr-16	*Dump truck*	R 1780 AB	13:45	15:26	1:41
8	24-Apr-16	*Dump truck*	R 1780 AB	5:30	8:10	2:40

As mentioned above time of arrival and departure when the waste transported once a day the truck will come in 5:30 AM then will depart at 8:10 PM or come at 11:50 PM and depart at 14:10 PM. time of arrival of the truck. Time of arrival and departure when the waste transported twice a day the truck will come in 5 AM and depart at 7:45 AM, then the truck came again at 12 PM and leave around 3 PM at the most. From the table 6 and 8 it also can be analyzed that the trucks arrive in TPS with empty container, and it requires approximately 1,5 - 2 hours to fill the container.

The quality of waste collection with dump truck are significantly depent on TPS which essentially consist of haul time and waiting time at the site [8]. Hence, scheduling is required so the waiting time that may accur in TPS can be minimized. Since TPS Patrakomala operated with unscheduled operation system, there is a time when dump truck and waste vehicles went to TPS at the same time, which cause either waste vehicles or dump truck need to wait each other performed. Another problem is there are collectors that unload the waste in TPS after the final truck transported to the landfill. Consequently, some amount of waste stays overnight in TPS Patrakomala. Therefore, operational schedule is required to adjust activities of waste collector and trucks hauling, which at the

end avoiding the waste unloaded in TPS Patrakomala for staying overnight to prefent there is wating time in TPS.

4 Conclusions

Several important conclusions can be drawn as follows:

1. TPS Patrakomala was identified as the most potential TPS to function as TPS 3R, based on several criteria. The limitation in some facilities will need an improvement to run as TPS 3R.
2. Currently TPS Patrakomalaoperated with unscheduled activities, there was no waste container and gate in TPS Patrakomala.
3. Land area available for TPS Patrakomala is 480 m^2. According to Regulation of The Minister of Public Works No 03, 2013 the area for TPS 3R should be more than 200 m^2. Therefore TPS Patrakomala has meet the requirement.
4. The operating waste vehicles were 4 conventional handcarts, 8 motor bikes, and 2 pick-up cars per day, with waste volumes respectively 1,4; 2,6; 3,6 m^3/trip. The average of waste collection is 2 trip/waste vehicle/day.
5. The dump truck to collect waste from TPS Patrakomala operated 1-2 trip/day, with capacities either 10; 13; 14 m^3, but the average of waste volume transported were respectively 20; 22; 26 m3/truck/trip which meant above its capacity there were still some waste unstransported from TPS.
6. Operational schedule is required to adjust activities of waste collector and truck, which at the end avoiding the waste unloaded in TPS Patrakomala for staying overnight or untransported to the landfill and waiting time in TPS.
7. Further, the presence of TPS 3R will facilitied the need of community, so the waste will be processed and reduced, supported by the the existence of operational management system.
8. The result of this study will be used to support operational of TPS 3R and other related data will be used to design TPS 3R, which is expectedly contribute to the improvement of waste management system in Bandung City

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